Earthquake model experiments in a viscoelastic fluid: A scaling of decreasing magnitudes of earthquakes with depth

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We performed shear deformation experiments using quasi-Maxwell fluids. We found that, depending on the strain rates, the same material generates earthquakes associated with the elastic rebound and deforms viscously. Around the threshold, elastic rebound releases a certain fraction of the interseismic displacement, but the other fraction remains as a result of the viscous relaxation. We applied our experimental results to a subduction zone, in which the upper part of the hanging wall behaves as an elastic layer and generates seismicity, while the deeper part behaves as a viscous fluid and subducts with the slab. Our experimental results suggest that, around the boundary of the elastic and viscous layers, seismicity can occur, but only some part of the interseismic displacements is released. The experimentally obtained threshold of the seismic activity is determined by the combination of the subduction velocity v, the viscosity of the hanging wall η, the fault length W, and the adhesive stress σ, $v\eta/(W\sigma)>1$. This threshold suggests that if the viscosity of the hanging wall decreases with depth, the maximum size of the earthquakes also decreases with depth, and, finally, seismicity disappears. This hypothesis is consistent with the observed fact that slow earthquakes, characterized by their small magnitudes, are observed at the downdip limit of the seismogenic zone.
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